CHASSIS Lubrication for SAFETY every 1,000 MILES

The Lubrication Engineer

NATIONAL LUBRICATING GREASE INSTITUTE

VOLUME VI • NUMBER 3 JUNE, 1942

Conical Cup for A. S. T. M. Penetration Test

PART I

By C. L. KNOPF[1]

The A.S.T.M. tentative method, (D217-38T), for the measurement of consistency of lubricating greases classifies cup greases reasonably well; however, light soda-soap greases and certain types of chassis lubricants may be considerably more than 100% in error, principally because of the great resistance offered by such products in being extruded through the small annular clearance space between the A.S.T.M. steel cone and the 3" diameter worker cup generally employed in the penetration test. At a penetration of 400 the cone diameter *(d)* and projected area (a) are 2.3" and 4.15 sq. inches, respectively, which leaves an annular area (α) of only 2.92 sq. inches; hence the annular ratio ($\frac{\alpha}{a}$) is 0.07 at 400 penetration, but should be not less than 9.00 if extrusion errors are to be avoided.

In experimenting with an early design of

(Continued on Page 6)

1—Staff Engineer, Sinclair Refining Company, East Chicago, Indiana.

L-597

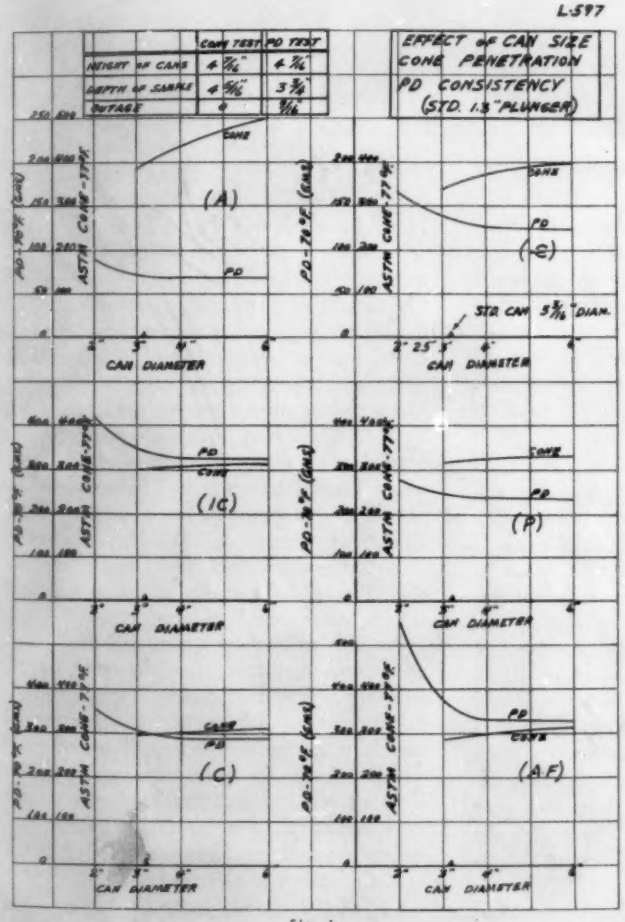

Fig. 1

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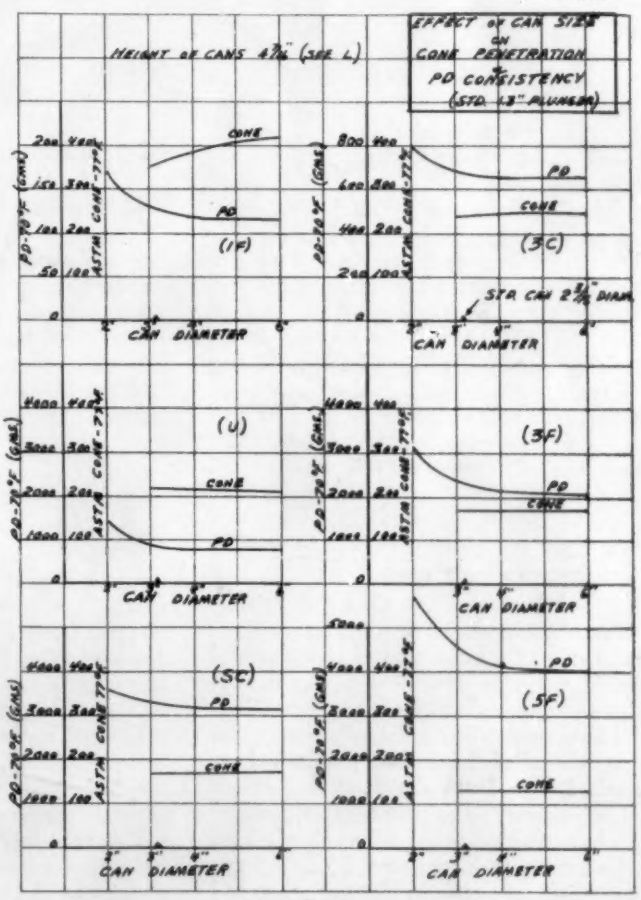

Fig. 2

Lubrication

THE ESSENCE OF ORDNANCE OPERATION AND MAINTENANCE

By CAPT. GEORGE H. SCHOENBAUM

(Continued from May Issue)

In certain instances, where extra equipment requiring lubrication is carried on the vehicle, it has been deemed advisable to separate the vehicle chassis from its accessory equipment. For example, the guide for a tractor equipped with a winch is shown with a tractor diagram on one side and the winch on the reverse side. A gun carriage will be shown on one side and the gun on the reverse side. In this way, each guide is complete for the unit for which it was designed, while at the same time the information contained is not crowded to a point where the guide becomes difficult to interpret or read.

War Department lubrication guides are being made a part of the accessory equipment for the materiel they cover, and it is believed that personnel, with little or no lubrication experience or mechanical background, can be readily trained to care for the equipment assigned to them. The Ordnance Department lubrication program, embracing the above-mentioned items, will enable those charged with the maintenance of ordnance materiel to expedite the training of men, to insure a standard of lubrication throughout the armed forces, and to provide complete protection of equipment. This new lubrication program will supersede all previous lubrication data issued to the field. Compliance with the lubrication instructions issued under the program will be mandatory upon the using arms.

No discussion of the Ordnance lubrication program would be complete without mentioning the importance of giving careful consideration to lubrication during the design and standardization of equipment. Careful investigation has repeatedly shown that many so-called lubrication problems have resulted from faulty design or the absence of satisfactory provisions for lubrication. Slight mechanical modifications already have solved many such problems. By incorporating satisfactory seals in the traversing and elevating gear housings on artillery materiel, the lubrication of these parts can, in the greater number of instances, be accomplished with oils, whereas in the past, cup greases have been used almost entirely.

Although it may be expedient to attempt to remedy some of the present difficulties by the use of "special lubricants," their final elimination will only result from improved design. Many benefits will result from the decision to standardize grease fittings on all vehicles procured and manufactured by the Ordnance Department. Many items now have as many as three different types of grease fittings, which is an obvious detriment, not only because of the many adapters required, but also because it makes the lubrication of such equipment more difficult and less likely to be accomplished satisfactorily.

FIG. 2. ORDNANCE LUBRICATING TRUCK

For the past several months, the Ordnance Department has been studying the design of mobile lubrication units which would be capable of rapidly lubricating a number of tanks or similar ordnance equipment. The primary function of the Ordnance Department, in this respect, is to advise the using arms as to the best method for lubricating the automotive materiel. In view of this, mobile lubrication units, issued to the using arms, will not be Ordnance vehicles. The basic requirements for such units are: first, it must be capable of simultaneously lubricating two vehicles at a time with all necessary lubricants; secondly, the vehicle must be capable of following a combat-vehicle column. One such unit (Fig. 2), manufactured by the Alemite Corporation to Ordnance requirements and specifications, has been assigned to the 30th Ordnance Company at Fort George G. Meade, Md., and this unit is now being given field trials at Fort Knox, Ky. To illustrate the speed with which vehicles may be serviced by such a unit, on a recent test with the Alemite truck it was possible to completely lubricate 4 light tanks in 18 minutes, whereas the normal time required to lubricate the same tanks was about 1½ hours. Completion of final designs is rapidly being accomplished, and mobile lubrication units will become a part of the Army's mechanized equipment in the near future.

It is obvious that any lubrication plan must be systematically followed up to insure its proper functioning. However, since the accomplishment of lubrication is, in all cases, either a function of the first or second echelon, no definite instructions concerning follow-up procedure can be prescribed by the Ordnance Department. It is expected that several important steps will be taken which will do much to call to the attention of the line organizations the importance of lubrication and the necessity for maintaining lubrication records.

Official approval recently has been secured for the assignment of qualified fuel and lubrication engineers to major Ordnance maintenance organizations in the field. Several lubrication follow-up systems have been devised at the instigation of the Ordnance Department and will be presented to the line organizations for their consideration. Enlargements of individual lubrication guides, suitable for instructional purposes, will be prepared and distributed to arm and service schools and training centers.

An educational program will be developed and instituted for the purpose of teaching proper methods of applying lubricants, and to advise operating personnel generally concerning the importance of fuels and lubricants in preventive maintenance. Government and industry have successfully used motion pictures for similar educational enterprises and consideration is being given to the adoption of this method.

In conclusion, it is well to point out that the success of our armed forces may very well depend upon good, sound, preventive maintenance. While lubrication, to the casual thinking person, may appear as a trivial detail, one must never forget that "the best

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laid plans o' mice and men gang aft agley" because someone neglected to take into consideration the extent to which some small oversight would affect the success of the "over-all" plans. Let not the mechanized forces which we now struggle to build and keep ready for action fail because someone forgot to keep intact the film of oil upon which a mechanized army must travel.

To those responsible for the inauguration and successful operation of the Ordnance lubrication program, it seems as though Benjamin Franklin's famous poem can well be paraphrased as follows:

For want of some oil, a bearing was lost;
For want of a bearing, an engine was lost;
For want of an engine, a tank was lost;
For want of a tank, a battle was lost;
For want of a battle, a democracy was lost;
And all for the want of a film of oil!

With apologies to its honorable author, we suggest this as a motto for those responsible for the lubrication of our modern mechanized equipment.

"This year, as never before, dealers' service stations are stocking profit items like CATTLEZE" according to officials of Calumet Refining Company, Chicago, "in order to take up in part the slack bound to be felt by tire and automobile rationing."

CATTLEZE, displayed with a mass array of cans like the one illustrated above, makes a strong bid for your farm trade.

The copy on the label reads, in brief, "Combats the fly problem. . . . A clean, clear spray that kills and repels stable and horn flies, for spraying cows, horses, mules, swine, stables and poultry houses."

Your farmer customer has only to read the complete directions on the label to be sold. And a trial will make him a steady customer.

EDITOR'S NOTE.—In a move to simplify the problem of supplying oil and gasoline to Army vehicles in the field, vastly complicated by the demands of motorized warfare, the War Department has announced that one standard type of gasoline will replace the four varieties formerly in use. This announcement embodies the findings of the War Department Committee on Liquid Fuels and Lubricants, which has made a study of the problem during the past several months.

The Army's standard gasoline is a high-test, 80-octane fuel like high-test commercial gasolines. Due to the better mileage it gives, as compared to lower-test fuels, it is expected that the Governments present drive for gasoline economy will be furthered by its adoption.

Fuels for diesel-powered vehicles will now be of three varieties instead of the former four, and lubricating oil for diesel vehicles has been similarly standardized.

Illustrations of Lubrication Guides shown on pages 4 and 5.

WOOL GREASES
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WAR DEPARTMENT LUBRICATION GUIDE

ORDNANCE DEPT. STARTING SERIAL No.—131. Located on plate on instrument panel.

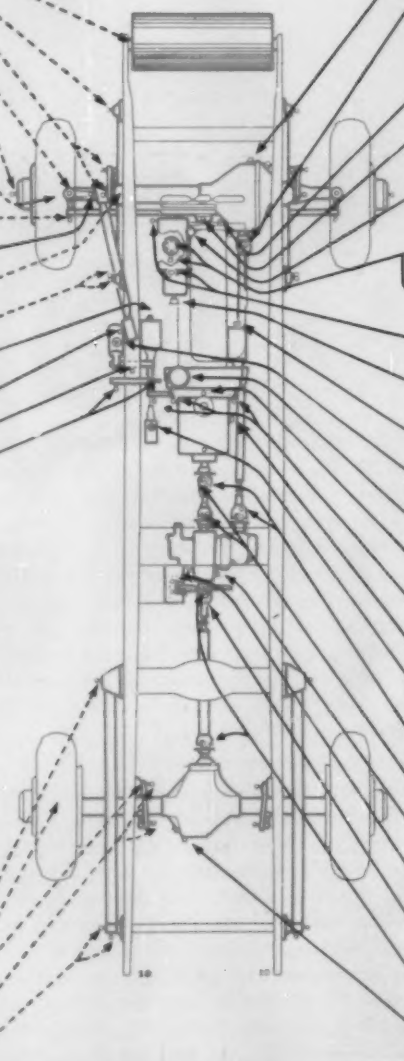
CAR, SCOUT, M3A1

TABLE OF CAPACITIES AND RECOMMENDATIONS

SNL G-67. Excerpt from TM 9-705

	Capacity	Above 90°	Lowest Expected Atmospheric Temperature				
			+32°	+10°	—10°	—30°	Below —30°
		SAE	SAE	SAE	SAE		
Crankcase	6 qt.	30	30	30	10	For operation in these temperature ranges, refer to OFSB 6-G-67 supplement.	
Transmission	5 qt.	140	140	90	80		
Differential (front)	4½ qt.						
Differential (rear)	3 qt.						
Transfer Case	3 qt.						

CAUTION Lubricate Dotted Arrow Points on BOTH SIDES



Lubricant / Interval

- Bumper Roller (Note 13) EO 1
- Spring Bolt CG 1
- Shock Absorber Links (Some models) CG 1
- Steering Knuckle Upper Brg. CG 1
- Universal Joint (Rzeppa) and Steering Knuckle Lower Brg. (Note 8) CG 1
- Front Wheel Brgs. (remove) (Note 7) WB 5
- Tie Rod CG 1
- Drag Link CG 1
- Shock Absorber (Fill to plug level) SA 5
- Spring Shackle CG 1
- Brake Vacuum Cyl. (plug) (Sparingly) VO 5
- Drag Link CG 1
- Clutch Relay Shaft CG 1
- Pedal Shaft CG 1

KEY

Lubricants	Intervals
EO —Engine Oil Crankcase grade	½— 500 miles
GO—Gear Oil	1—1,000 miles
CG—Chassis Grease No. 0 (below 32° F.) No. 1 (above 32° F.)	2—2,000 miles
WB—Wheel Bearing Grease No. 2	5—5,000 miles
WP—Waterproof Grease No. 4	
PO —Penetrating Oil	
SA —Shock Absorber Fluid (Note 6)	Check Daily — Crankcase and Air Cleaners
HB —Hydraulic Brake Fluid	
VO —Vacuum Cylinder Oil	

- Spring Bolt CG 1
- Rear Wheel Brgs. (remove) (Note 7) WB 5
- Shock Absorber (Fill to plug level) SA 5
- Shock Absorber Links (Some models) CG 1
- Spring Shackle CG 1

Interval / Lubricant

- 5 GO Front Axle Diff. (See Table) (Note 5)
- 1 GO Universal Joint (Note 9)

Serviced From Under Hood

- 1 CG Engine Trunnion Bearing
- 1 EO Fan (plug) (fill reservoir)
- 1 EO Crankcase (See Table) Drain, flush, refill. (Note 2) Check level daily
- 1 EO Distributor (sparingly) WB (late models, grease cup)
- 2 EO Wick under rotor (Note 10)
- 1 EO Generator (sparingly)
- ½ WP Water Pump Shaft (gr. cup) (Turn cup 1 full turn)
- 1 EO Starter (sparingly) (Note 12) (Reached from under car)
- 1 GO Steering Gear (plug)
- 5 *Oil Filter* (Note 11)

- ½ EO Clutch Release Bearing
- 1 CG Clutch Shaft
- 5 GO Transmission (See Table) (Note 5)
- 1 HB Brake Master Cylinder (Refill to ¾ in. below hole)
- 1 GO Univ. Slip Joint (Note 9)
- 1 GO Universal Joints (Note 9)
- 5 GO Transfer Case (See Table)
- 1 CG Propeller Shaft Brake
- 1 GO Univ. Slip Joint (Note 9)
- 1 GO Universal Joints (Note 9)
- 5 GO Rear Axle Diff. (See Table) (Note 5)

NOTES Additional Lubrication and Service Instructions on Individual Units and Parts NOTES

1. AIR CLEANERS—(Engine) Check level and refill oil cup to bead level daily with EO. Drain, clean and refill every 100 to 1,000 miles, depending on operating conditions. Every 2,000 miles, also remove air cleaner and wash all parts. (Brake Vacuum Cylinder) Every 3 months remove brake vacuum cylinder air cleaner, located under hood, clean hair and recil with EO.
2. CRANKCASE—Drain only when engine is hot. Flush with 4 qt. SAE 10, idle engine 5 minutes and drain. Refill to FULL mark on gage. CAUTION: Be sure pressure gage indicates oil is circulating. See Table.
3. INTERVALS indicated are for normal service. For extreme conditions of speed, heat, water, mud, snow, rough roads, dust, etc., change crankcase oil and lubricate more frequently.
4. FITTINGS—Clean before applying lubricant. Lubricate until new grease extrudes from the bearing. CAUTION: Always lubricate chassis lubrication points after washing vehicle.
5. GEAR CASES—Check level every 1,000 miles, add lubricant if necessary. Drain, flush and refill at end of first 1,000 miles; thereafter as indicated at points on guide.
6. SHOCK ABSORBERS — (Houde) Refill with Shock Absorber Fluid, Heavy. (Delco) Refill with Shock Absorber Fluid, Light.
7. WHEEL BEARINGS (Front and rear) — Remove wheel, clean and repack bearings.
8. RZEPPA UNIVERSAL JOINTS (Front wheels)—Remove level plug in rear of joint and fill through fitting in wheel hub to level of plug opening.
9. UNIVERSAL JOINTS AND SLIP JOINTS—Use same grades of GO as used for gear cases. Apply lubricant to joint until it overflows at relief valve, and to slip joint until lubricant extrudes.
10. DISTRIBUTOR—Wipe distributor breaker cam lightly with CG every 2,000 miles.
11. OIL FILTER—Renew filter element every 5,000 miles or oftener if necessary. After renewing element, refill crankcase to FULL mark on gage.
12. STARTER—Remove starter every 5,000 miles, clean, and lubricate Bendix drive sparingly with PO.
13. OIL CAN POINTS — Lubricate throttle and spark control rod ends, clevises, hinges, latches, bumper roller and pintle with GO every 1,000 miles.
14. POINTS REQUIRING NO LUBRICATION— Springs, Shock Absorber Links (some models, rubber).
15. POINTS TO BE LUBRICATED BY ORDNANCE MAINTENANCE PERSONNEL AT TIME OF GENERAL OVERHAUL — Clutch Pilot Bearing, Speedometer Cable.

WAR DEPARTMENT LUBRICATION GUIDE

CARRIER, MORTAR, 81 mm, HALF TRACK, M4

MFR'S STARTING SERIAL No.—M3-2.
Located on plate on instrument panel.

TABLE OF CAPACITIES AND RECOMMENDATIONS

SNL G-102 Excerpt from TM 9-710.

	Capacity	Above 90°	Lowest Expected Atmospheric Temperature				
			+32°	+10°	—10°	—30°	Below —30°
Crankcase	12 qt.	SAE 30	SAE 30	SAE 30	SAE 10	For operation in these temperature ranges, refer to OFSB 6-G-3.	
Trans. and Transfer Case	7½ qt.	140	140	90	80		
Differential (Front)	3½ qt.						
Differential (Rear)	6 qt.						

CAUTION Lubricate Dotted Arrow Points on BOTH SIDES

Lubricant ● Interval

- Spring Bolt CG 1
- Shock Absorber SA 5
- Universal Joint (Rzeppa) CG 1 (Note 7)
- Steering Knuckle, Upper and Lower CG 1
- Wheel Bearings (remove) WB 5 (Note 6)
- Tie Rod CG 1
- Drag Link CG 1
- Spring Shackle CG 1
- Drag Link CG 1
- Steering Gear GO 1 (Seasonal grade)
- Pedal Shaft CG 1
- Clutch Relay Shaft CG 1
- Brake Master Cylinder HB 1 (Refill to ¾" below hole)
- Brake Vacuum Cyl. (plug) VO 5 (sparingly)
- Clutch Cross Shaft CG 1
- Disc Brake CG 1

NOTE — See Reverse Side for lubrication of Track Suspension System

Interval ● Lubricant

- 5 GO Front Axle Diff. (See Table) (Note 5)

Serviced From Under Hood

- 1 WB Generator (grease cups) (Refill cup, turn 1 full turn)
- 1 CG Front Engine Support
- 2 *Oil Filter* (Note 10)
- 1 GO Universal Joint (SAE 140) (Reached from under vehicle) (Note 8)
- 1 EO Crankcase (See Table) Drain, flush, refill. (Note 2) Check level daily
- 1 WB Distributor (grease cup) (Refill cup, turn 1 full turn)
- 2 EO Wick under rotor (Note 9)
- 1 WB Tachometer Drive (Refill cup, turn 1 full turn)
- 1 EO Starter (oilers) (sparingly) (Some models 2 oilers) (Note 11)
- CG Reduction Gear Case (plug) (Note 12)

- 1 GO Universal Slip Joint (SAE 140) (Note 8)
- 1 GO Universal Joint (SAE 140) (Note 8)
- 1 WB Clutch Release Brg. (fitting) (Remove bottom plate of clutch housing)
- 5 GO Trans. and Transfer Case (See Table) (Note 5)
- 1 GO Universal Slip Joint (SAE 140) (Note 8)
- 1 GO Universal Joint (SAE 140) (Note 8)
- 5 GO Rear Axle Diff. (See Table) (Note 5)
- 1 CG Idler Support Brgs.

KEY

Lubricants	Intervals
EO —Engine Oil Crankcase grade GO—Gear Oil CG—Chassis Grease No. 0 (below 32° F.) No. 1 (above 32° F.) WB—Wheel Bearing Grease No. 2 PO —Penetrating Oil SA —Shock Absorber Fluid, Heavy. HB —Hydraulic Brake Fluid VO —Vacuum Cylinder Oil	1—1,000 miles 2—2,000 miles 5—5,000 miles Check Daily Crankcase and Air Cleaners

NOTES Additional Lubrication and Service Instructions on Individual Units and Parts NOTES

1. AIR CLEANERS—(Engine) Check level and refill oil cup to bead level daily with EO. Drain, clean and refill every 100 to 1,000 miles, depending on operating conditions. Every 2,000 miles, also remove air cleaner and wash all parts. (Brake Vacuum Cylinder) Every 3 months remove brake vacuum cylinder air cleaner, located under hood, clean hair and recoil with EO.
2. CRANKCASE—Drain only when engine is hot. Flush with 8 qt. SAE 10, idle engine 5 minutes and drain. Refill to FULL mark on gage. CAUTION: Be sure pressure gage indicates oil is circulating. See Table.
3. INTERVALS indicated are for normal service. For extreme conditions of speed, heat, water, mud, snow, rough roads, dust, etc., change crankcase oil and lubricate more frequently.
4. FITTINGS—Clean before applying lubricant. Lubricate until new grease extrudes from the bearing. CAUTION: Always lubricate chassis points after washing vehicle.
5. GEAR CASES—Check level every 1,000 miles, add lubricant if necessary. Drain, flush and refill at end of first 1,000 miles; thereafter as indicated on guide. Check with vehicle on level ground.
6. FRONT WHEEL BEARINGS—Remove wheel, clean and repack bearings, also remove, clean and lubricate spindle bushing with WB.
7. RZEPPA UNIVERSAL JOINTS (Front wheels) — Remove level plugs, fill through rear plug hole until lubricant is level with opposite hole. Every 5,000 miles remove, clean and inspect universal joints. Reassemble, remove plug in spindle, insert fitting and inject 1 lb. CG. Replace plug. Refill universal joint housing.
8. UNIVERSAL JOINTS AND SLIP JOINTS — Apply lubricant to joint until it overflows at relief valve and to slip joint until lubricant extrudes from vent at universal joint end of spline.
9. DISTRIBUTOR—Wipe distributor breaker cam lightly with CG and lubricate breaker arm pivot with EO sparingly every 2,000 miles.
10. OIL FILTER—Renew filter element every 2,000 miles of oftener if necessary. After renewing element, refill crankcase to FULL mark on gage.
11. STARTER—Remove starter every 5,000 miles, clean, and lubricate Bendix drive sparingly with PO. Lubricate Bendix drive shaft outer bearing through oiler with EO.
12. STARTER REDUCTION GEAR CASE — Every 6 months remove plug in top of housing and refill with CG.
13. OIL CAN POINTS—Lubricate throttle ends, clevises, hinges, latches, vacuum cylinder valve and power lever linkage, bumper roller slides and bushings and pintle with EO every 1,000 miles.
14. POINTS REQUIRING NO LUBRICATION — Springs, Shock Absorber Links, Bumper Roller Brgs., Water Pump and Fan.
15. POINTS TO BE LUBRICATED BY ORDNANCE MAINTENANCE PERSONNEL AT TIME OF GENERAL OVERHAUL — Clutch Pilot Bearing, Speedometer Cable (See OFSB 6-G-102).

(Continued from Page 1)

a 2½-gram miniature consistometer, (7/16" diameter cup and 7/32" nail-shaped plunger), it was learned that this annular ratio of 3 was even too low, as proven by the following tests on four types of greases, of same consistency when accurately measured.

Note that increasing the viscosity of the oil in a calcium grease has only a small effect on the consistency, whereas a fibre grease, type 3, with 100" vis. oil is 24% greater than No. 1. Type No. 4 (cylinder stock-soda soap) has a consistency 68% greater than No. 1. With cone penetration of 300, errors are even greater than in the above tests, since the adhesion of the grease to the conical surface may add another 25 or 50% to the extrusion error.

	Calcium Soap		Soda Soap	
	No. 1	No. 2	No. 3	No. 4
Mineral Oil Vis. 100°	100"	750"	100"	150" at 210°F.
Relative Reading	1.00	1.08	1.24	1.68

In a very thorough research, a dozen greases of different types and grades were tested in cans varying from 2" to 6" in diameter, by penetrating with the A.S.T.M. steel cone and the 1.3" P.D.-Disc Plunger. Fig. 1 and Fig. 2 show the effect of can-size on the consistency, as measured by the two devices. The trend of these curves indicates that cone readings, especially those of about 400 Pen., reach maximum values, or minimum consistency, when the can diameter is about 7" or 8". The P.D. readings appear to reach minimum values with 4" diameter cans. A series of tests in which the plunger diameter was varied confirmed the above conclusions, that correct readings are impossible with annular ratios less than 9.

Fig. 2 shows (IF), (No. 1 Fibre Gr.), to be about 430 pen. in a 7½" can, but only 350 in a 3" can, or 80 units off, which is an error of 100% due to extrusion alone. The P.D. reading in the 2" cup has an error of 42% although appearing to be greater than the cone error. The P.D. errors in other curves are likewise exaggerated 2 or 3 times as much as are their corresponding cone errors. No. 1 cup grease (1 C) appears to have a P.D.—2" can error 3 or 4 times that of the cone—3" cup while actually the errors are 30 and 56% respectively.

Fig. 3 is a summary of the can-size and plunger-size investigation, showing errors due to extrusion, and to adhesiveness of semi-fluid products when tested by plungers too small in diameter. By reference to the scales at the bottom, errors at different ($\frac{A}{a}$) ratios, or any particular penetration value, may be learned. Note that ($\frac{A}{a}$) =9 is taken as correct (or unity), corresponding with a penetration of 230.

Fig. 5 gives valuable data relative to penetration limits at ($\frac{A}{a}$)=9, for containers of various diameters. A penetration of 397 should be free from extrusion error in a 10 lb. pail of 7¼" diameter, and a 330 penetration satisfactory in a 5½" container.

Fig. 4 is a photograph of the proposed conical cup (5½" diameter x 2" high), which requires a sample slightly less than the A.S.T.M. worker cup, allowing for a small discard. Great care has been taken in the design of this device so that the most desirable shape and dimensions should be adopted. Cross-sectional view, Fig. 7, shows how ideally the shape is suited to the A.S.T.M. cone.

Working drawings of the cup, cover, thermometer holder and reamers are shown in Fig. 6.

(To Be Continued)

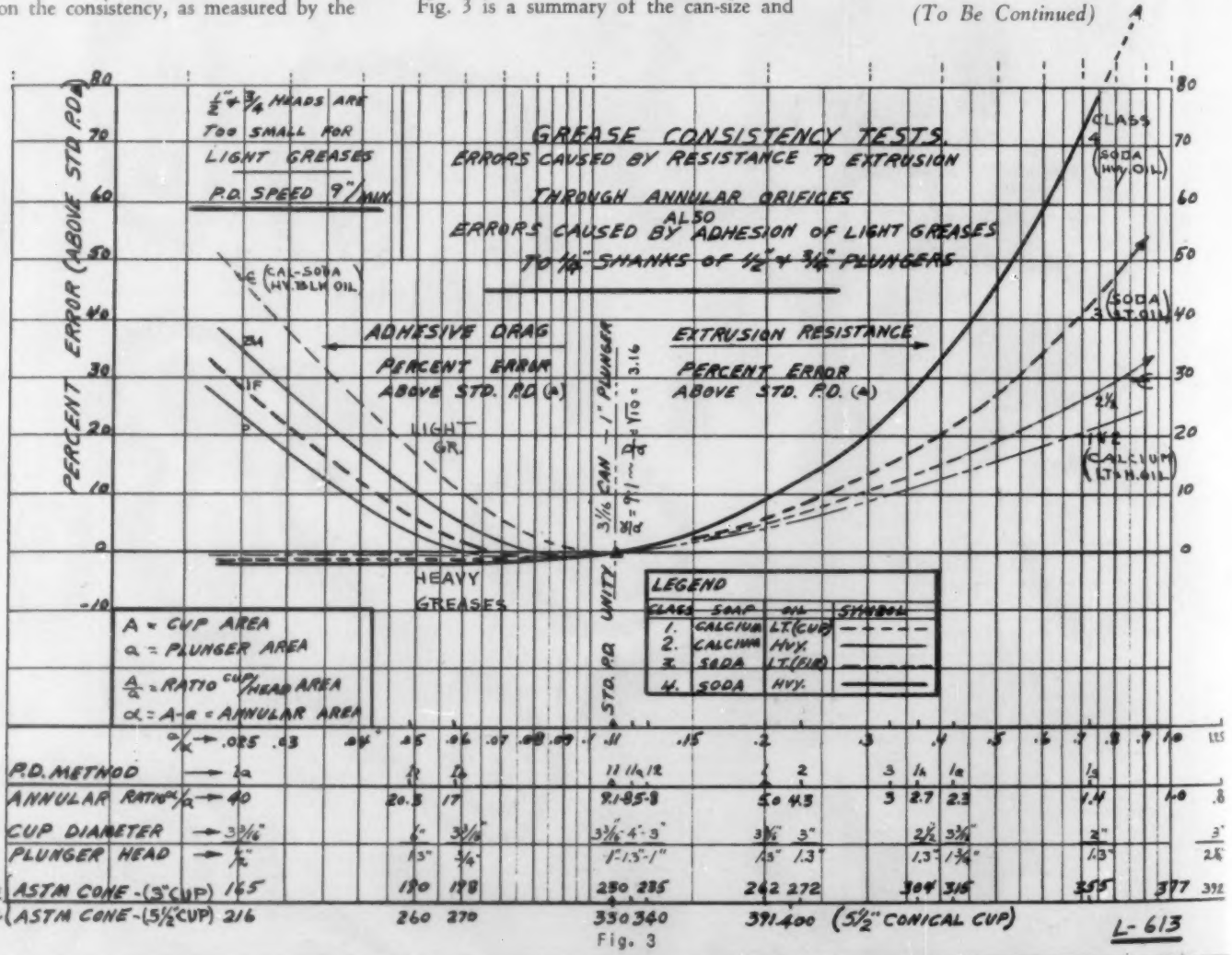

GREASE CONSISTENCY TESTS.
ERRORS CAUSED BY RESISTANCE TO EXTRUSION THROUGH ANNULAR ORIFICES
ALSO
ERRORS CAUSED BY ADHESION OF LIGHT GREASES TO ½" SHANKS OF ½" & ¾" PLUNGERS
½" & ¾" HEADS ARE TOO SMALL FOR LIGHT GREASES
P.D. SPEED 9"/MIN.
ADHESIVE DRAG
PERCENT ERROR ABOVE STD. P.D. (▲)
EXTRUSION RESISTANCE
PERCENT ERROR ABOVE STD. P.D. (▲)
PERCENT ERROR (ABOVE STD. P.D.▲)
STD. P.D. UNITY
HEAVY GREASES
LIGHT GR.
A = CUP AREA
a = PLUNGER AREA
A/a = RATIO CUP/HEAD AREA
α = A-a = ANNULAR AREA
LEGEND
CLASS | SOAP | OIL | SYMBOL
1. CALCIUM | LT(CUP)
2. CALCIUM | HVY.
3. SODA | LT(FIB)
4. SODA | HVY.
P.D. METHOD
ANNULAR RATIO A/a
CUP DIAMETER
PLUNGER HEAD
SAME A/a ASTM CONE -(3"CUP) 165
ASTM CONE -(5½"CUP) 216
(5½" CONICAL CUP)
L-613

Fig. 3

FIG. 4

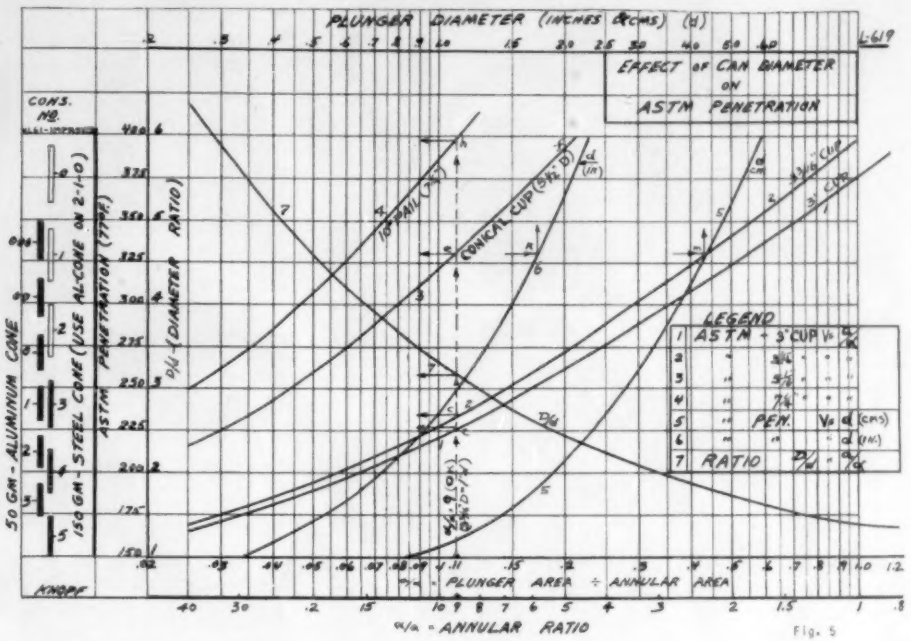


Fig. 5

ALL GRADES OF GRAPHITE
FOR THE GREASE & OIL COMPOUNDER
EXCELLENCE D SINCE 1827
JOSEPH DIXON CRUCIBLE CO.
JERSEY CITY, N. J.

2661

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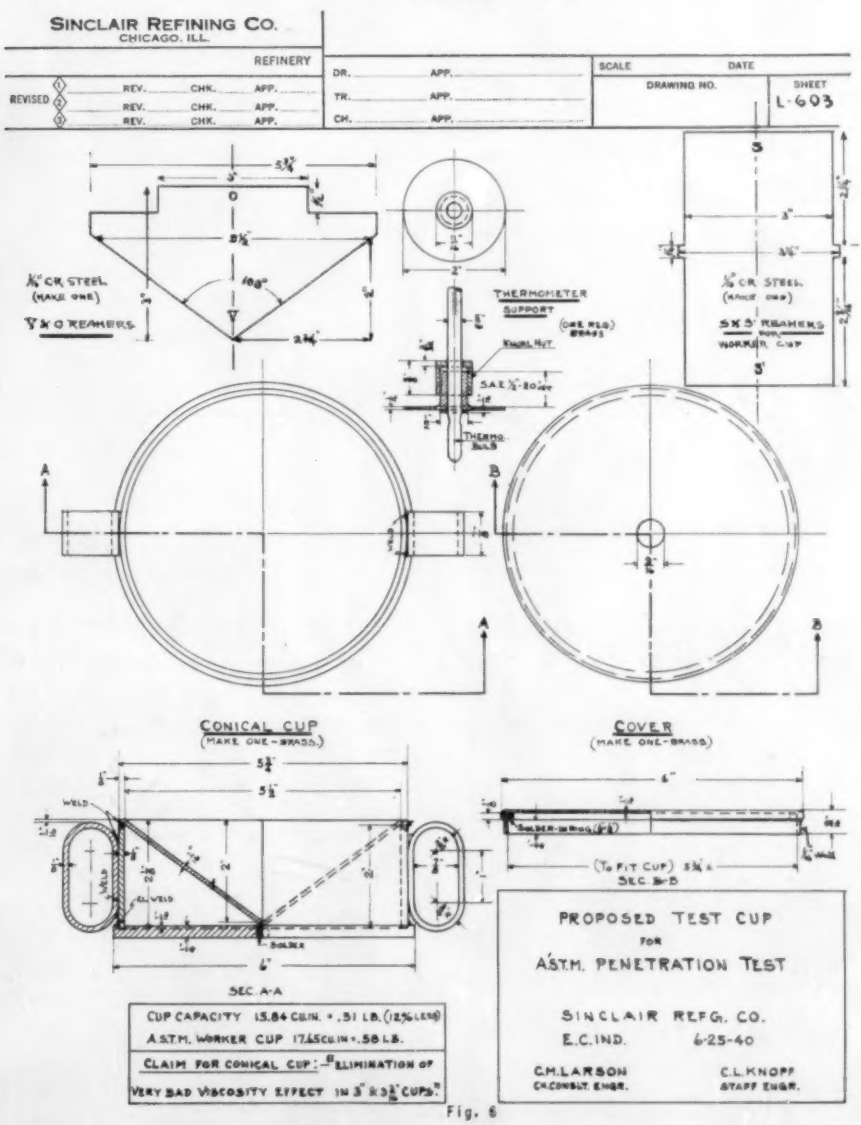

Fig. 6

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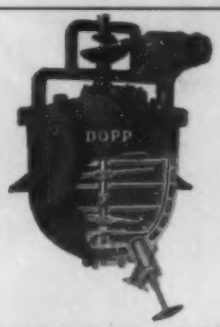
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